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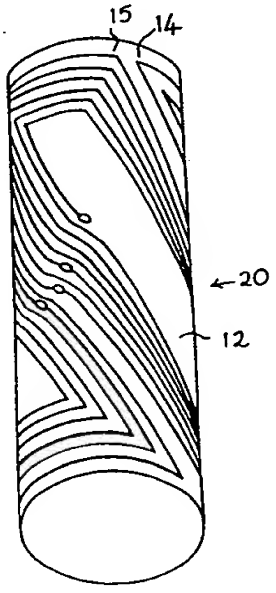
(71) Applicant: DEVELOPMENT FINANCE CORPORATION OF NEW ZEALAND, 350 Queen Street, Auckland (NZ)

(72) Inventor: Weatherly, John Deane, 54, Collie Street, Manurewa Auckland (NZ)

(74) Representative: Calderbank, Thomas Roger et al, MEWBURN ELLIS & CO. 2/3 Cursitor Street, London EC4A 1BQ (GB)

(54) Electric coil.

(57) An electric coil is printed onto a flexible sheet so that it can be bent into any desired shape to create a complex magnetic field. A flexible parallelogram substrate, having a two-coil pattern printed thereon, can be bent into a cylinder so that the coil pattern at the ends of the cylinder generate an axial magnetic field whilst the remainder of the coil pattern on the cylinder can generate a transverse field varying continuously through 90°.



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ELECTRIC COIL

This invention relates to an electric coil.

In the past, coils have typically been formed of a length of wire wrapped around an axis. An electric current passed through the coil will cause a magnetic field to form around the coil.

If a magnetic field of complex shape is required, then either several coils are required to make up the field, or the coil must be formed in a complex shape. The winding of a complex-shaped field is complicated and expensive, and so the multiple-coil option is often used. This is still several times the expense of a single, simple coil, however.

Coils printed onto a flat circuit board have been used in the past, notably in certain television circuits. This has been found to be an inexpensive and effective method of forming a magnetic field. Such coils, however, give rise only to simple magnetic fields.

It is an object of the present invention to provide a means of forming a complex magnetic field economically.

Accordingly, in a first aspect, the present invention broadly consists in a method of forming a magnetic field, the method comprising the steps of printing a coil of conductive material onto a sheet of substantially flexible material, bending the sheet to a desired shape, and passing an electric current through the coil.

Preferably, more than one coil is printed onto the sheet.

Preferably, the coil is printed in the shape of a parallelogram.

Preferably, the sheet is bent into a coil.

In a second aspect, the present invention broadly consists in a coil comprising a substantially flexible sheet and a spiral of conductive material adhered to the sheet.

The above gives a brief description of the invention, a preferred form of which will now be described by way of example with reference to the accompanying drawings.

Figure 1 is a plan view of a coil of the present invention; and

Figure 2 is a view of the coil of Figure 1 in an alternative configuration.

Figure 3 shows the coil of Figure 2 secured to a hollow cylindrical core.

The drawings show two coils 10, 11 printed onto a flexible sheet or substrate 12. Each coil is a spiral and, in the illustrated embodiment, is in the shape of a parallelogram. Thickenings 13 in the printed line provide convenient electrical contact points. There may typically be two end contacts, a centre contact for connexion to a power supply or the like, and two additional contacts either side of the centre tap for impedance matching purposes.

The coils are typically printed in copper or other conductive material onto a flexible plastics sheet. A preferred material is a flexible epoxy fibreglass sheet.

In Figure 2 the sheet 12 is shown curved over to form a cylinder by joining corner 14 to corner 15, and joining corner 16 to corner 17. The cylinder 20 of Figure 2 is drawn to a larger scale than that of Figure 1. Nevertheless the circumference of the cylinder 20 is the distance along side 14 - 15 of sheet 10 whilst the length of the cylinder 20 is the distance between corner 15 and point 18 of sheet 10. (Point 18 being opposite to the corner 17).

It will be generally convenient to wrap the sheet 10 around an electrically insulating hollow cylindrical core 22 (shown in Figure 3). This may conveniently be a PVC (polyvinylchloride) pipe with the sheet 10 wrapped around the pipe and held in place by straps, or bands, e.g. plastic straps 23, 24 heat shrunk onto the sheet. Figure 3 also shows on join line 25 between edges 14 - 17 and 15 - 16 (the spiral coils have been omitted for the sake of clarity).

If a current is passed between the two end contacts 13 on the sheet, a complex magnetic field suitable for use in the apparatus described in European Patent Specification Serial # 83.307602.9 is produced. In that specification, the coil is described as being "several coils, or a single coil with taps in a complex pattern". The present invention provides a very simple and effective substitute for the complex coil arrangement of that specification.

In particular, that specification calls for a magnetic field with three axes of magnetic orientation, for detecting the two frequencies of tuned elements within balls rolling through the field. These magnetic axes were in the axial, transverse horizontal and transverse vertical directions. The spiral coil illustrated in Figure 2 achieves the same effect by using the end windings for the axial component, and the transverse field that varies continuously from horizontal to vertical along the helix from one end of the field to the other.

This removes field discontinuities from the coil, but involves a revised method of ball recognition that determines the ball number after multiple scans as opposed to the scheme described in that specification of having to find both ball frequencies within the same scan. The scan rate is typically about 100 per second.

Various modifications to the above may be made without departing from the scope of the present invention as broadly defined or envisaged. For example, many different coil patterns may be printed onto a sheet in place of the two-coil pattern illustrated. Any pattern of one or more coils may be printed in large quantities very cheaply.

Similarly, a sheet with a coil pattern printed on it can be bent into any desired shape, other than the cylinder described above.

If desired, there may be coils printed on both sides of the substrate, so that they overlap to produce a complex field. Alternatively, two or more substrates may be sandwiched together to achieve a similar result.

Printed coils may, of course, be cut and joined together in different arrangements to achieve different field shapes.

CLAIMS:

1. A method of forming a magnetic field, the method comprising the steps of printing a coil of conductive material onto a sheet of substantially flexible material, bending the sheet to a desired shape, and passing an electric current through the coil.

2. A method as claimed in Claim 1 wherein more than one coil is printed on the sheet.

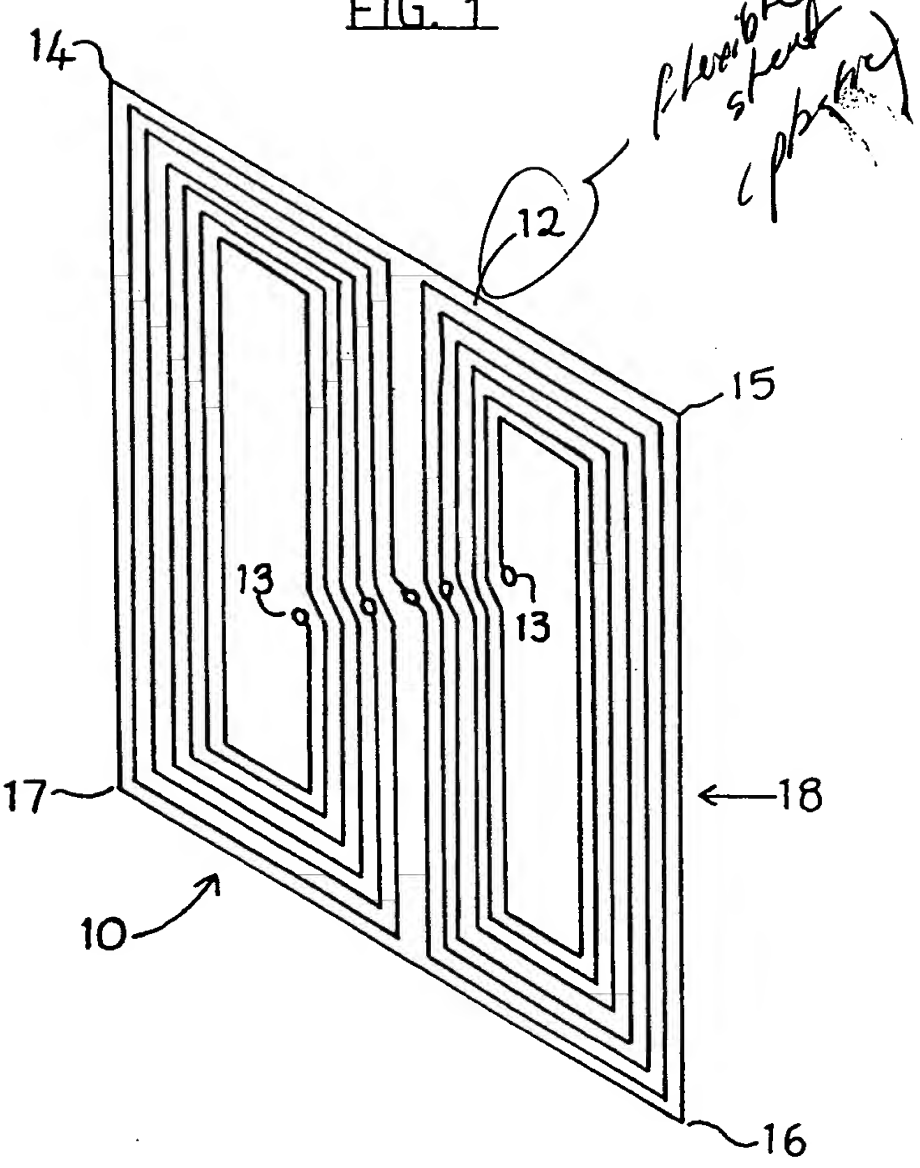
3. A method as claimed in Claim 1 wherein the coil is printed in the shape of a parallelogram.

4. A method as claimed in claim 1, wherein the sheet is bent into a cylinder.

5. A coil comprising a substantially flexible sheet and a spiral of conductive material adhered to the sheet.

6. A coil as claimed in claim 5 wherein the flexible sheet is in the form of a parallelogram having two parallelogram shaped spiral electrically conductive circuits printed thereon and the parallelogram sheet has been bent into a cylinder.

FIG. 1



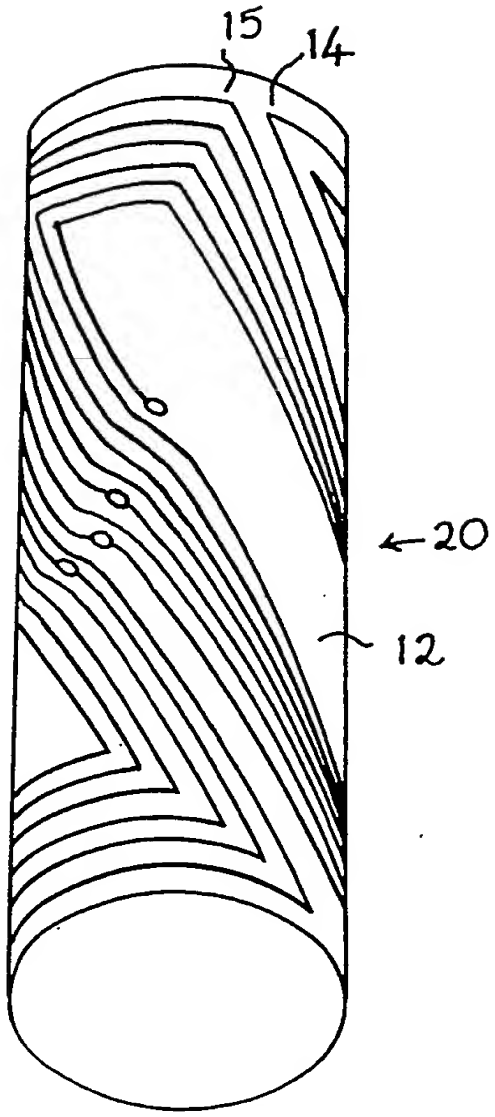


FIG. 2

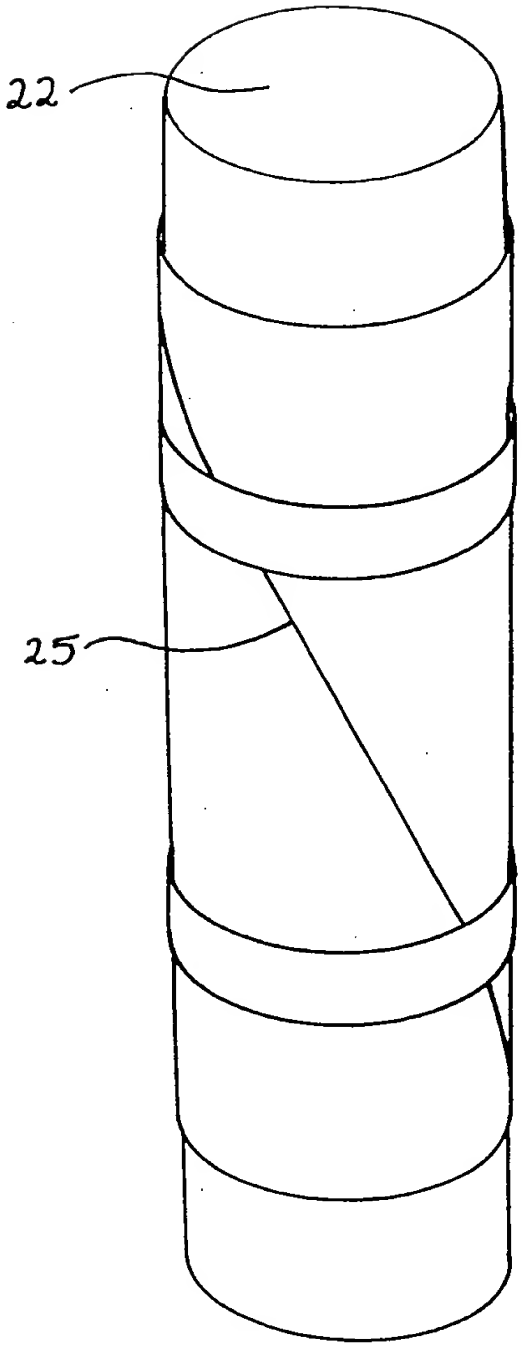


FIG. 3